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GROWTH, STRUCTURAL CHANGE AND TECHNOLOGICAL CAPABILITIES

LATIN AMERICA IN A COMPARATIVE PERSPECTIVE

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Growth, Structural Change and Technological Capabilities Latin America in a Comparative Perspective

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Growth, Structural Change and Technological Capabilities
Latin America in a Comparative Perspective♣

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Abstract

Countries differ in terms of technological capabilities and complexity of production structures. According to that, countries may follow different development strategies: one based on extracting rents from abundant endowments, such as labor or natural resources, and the other focused on creating rents through intangibles, basically innovation and knowledge accumulation. The present article studies international convergence and divergence, linking structural change with trade and growth through a North South Ricardian model. The analysis focuses on the asymmetries between Latin America and mature and catching up economies. Empirical evidence supports that a shift in the composition of the production structure in favor of R&D intensive sectors allows achieving higher rates of growth in the long term and increases the capacity to respond to demand changes. A virtuous export-led growth requires laggard countries to reduce the technological gap with respect to more advanced ones. Hence, abundance of factor endowments requires to be matched with technological capabilities development for countries to converge in the long term.

Key words: Latin America, Structural Change, Technological Capabilities, Growth
JEL Classification: **O30, O33**

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Introduction

The capability to promote structural change in order to profit from new technological paradigms and demand growth is a critical determinant of a country relative economic performance in the international arena. And, this is mostly true in open economies, where products, production processes and sectors internationally emerge and disappear at a high pace.

Actually, the relationship between structural change and economic development traces back to the analyses of the development theory pioneers. In the fifties, development required the reallocation of production factors from low productivity to high productivity sectors where increasing returns prevailed[3], and hence industrialization was seen as the way out from the "peripheral" condition. The manufacturing sector would allow increasing returns to ensue and technological learning to develop; and an increasing participation of industry in total value added would grant spillover effects, backward and forward linkages and technological externalities, which in turn would accelerate capital accumulation and growth[4].

Within this framework, production structure transformation would, gradually, lead to a change in the international specialization pattern. Prebisch (1950;1981) emphasized that the production structure of peripheral countries implied a much higher income elasticity of demand for imports than their income elasticity of demand for exports, thus inducing recurrent external imbalances in the those countries. Assuming low price elasticities of import and export demand, the South would have to grow at lower rates than the North to avoid external disequilibrium (Rodriguez, 1981). This implies divergence in income per capita between North and South, which could only be avoided by a reorientation of the relative specialization.

This view on structural change and development has been enriched in the 1960s by some new contributions in the technology and trade theory (Posner, 1961; Freeman, 1963; Hirsch, 1965; Vernon, 1966). International asymmetries in technological capabilities started to be regarded as main determinants of trade flows and specialization patterns, hence influencing economic growth[5]. Knowledge and technology leave the free good domain and are converted in oligopoly assets that confer a significant competitive advantage to those who innovate.

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[3] Hirschman, Prebisch, Rosenstein-Rodan, Gerschenkron, Chenery and Sirkin are some of the classical authors in the development theory. For a reviewof their contributions see Ray (1998, Chapter 5).

[4] Recently, these "old" issues, such as as: externalities, indivisibilities, spillovers and increasing returns are evoked in the "new growth theories" (Grossman and Helpman, 1992; Krugman, 1991; Aghion and Howitt, 1998; Ray, 2000; Ros, 2000). Diversification in production structures and increasing returns in R&D intensive sectors explain sustained per capita income growth in the long term and structural change depends on the creation of new capital assets, increasing labor division and improvements in the quality of the industrial produce. At the same time, the innovation pace of the R&D intensive sectors sustains production structure diversification and increasing returns.

[5] Freeman (1963) highlights the differences that determine the specialization pattern before and after the imitation process. At the initial stages of the innovation process the influence of patents, commercial secrecy, static and dynamic economies of scale prevail. Once the imitation occurs, the traditional process of adjustment in production cost reshapes the specialization pattern. In Hirsch (1965) and Vernon (1966), as well, technological asymmetries are associated with

This perspective is also the distinctive feature of the evolutionary school, which emphasizes the role of technological change in shaping structural change and growth (Dosi *et al* 1990). Economies that are able to absorb new technological paradigms and that transform their production structure increasing the participation of R&D intensive sectors or production stages will converge. Three relevant implications emerge from this approach.

First, the evolutionary theory predicts persistent asymmetries in production capabilities. At any point in time two major testable conjectures can be drawn: (i) different countries can be unequivocally ranked both according to the efficiency of their average production techniques and, in the product space of the price-weighted performance, according to the characteristics of their outputs, irrespectively of relative prices; (ii) there will be no significant relationship between these gaps and international differences in the capital/output ratios. The capability to develop new products and the capacities to imitate already existing ones will be extremely skewed. Indeed, the international distribution of innovative capabilities is at least as uneven as that regarding the production processes.

Second, development and industrialization are strictly linked to inter- and intra--national diffusion of "superior" techniques. At any point in time there is likely to be only one or at most very few "best practice" production techniques that correspond to the technological frontier. In the case of developing economies, industrialization is thus closely associated with the transfer, imitation and adaptation of established technologies from more advanced economies. Capabilities of adopting and adapting technologies are, in turn, influenced by the specific capabilities of each economy.

Third, evolutionarists emphasize the importance of the institutional dimension for production and innovation development. Actually, at a micro level, technologies embedded in particular institutions, the firms, whose characteristics, decision rules, capabilities, and behaviors directly shape the pace and directions of technological advance. Within this framework the concept of "national innovation system" ensues as a relevant dimension for understanding the relative performance of countries in international competition (Cimoli and Dosi 1995; Freeman, 1987; Nelson, 1993).

different phases in the evolution of technology and the international distribution of innovative capabilities. Innovative capabilities are the main competitive asset, which explains the production of new commodities in the advanced countries. Over time, technology evolves toward a mature phase characterized by standardization of products and processes. At this point, productivity improvements and production costs advantages in the mature technology are basis for trade.

Actually, technological and institutional gaps and asymmetries can jointly reproduce themselves over rather long spans of time, or, conversely, it might be precisely the institutional and technological diversity among countries that may foster catching-up (and, in some rare cases, leapfrogging) in innovative capabilities and per capita income. And, it is within this evolutionary micro-theory that we are going to analyze the evolution of technological capabilities, structural change and growth of Latin America in a comparative perspective.

The paper is organized in four sections. Section I develops a simple model of convergence and divergence, based on Cimoli (1988) and Fagerberg (1988). Section II discusses the transformation of the Latin America production structure in terms of technological capabilities and international competitiveness, showing that the virtuous link between exports and output growth requires a reduction in the technological gap with respect to more advanced economies. On the basis of these analyses, section III identifies two types of countries' rent seeking strategies: one which exploits the opportunities offered by the relative abundance of natural resources or labor and the other based on the capacity to extract rents from technological capabilities. Section IV concludes.

1 A Model of Convergence and Divergence

Empirical evidence on international trade and convergence suggests that caution is needed when exploring the impact of trade on the specialization pattern. In conventional models, international trade is expected to contribute to convergence by inducing the adoption of new technologies and by encouraging a more efficient allocation of resources (see for instance Barro and Sala-i-Martín, 1994). Therefore, there should be a positive association between openness and economic growth. But this perspective is challenged by that literature pointing out that convergence and openness have not always gone hand by hand (Easterly, 2001; Rodríguez and Rodrik, 2001). Convergence or divergence, in these cases may depend on whether openness is complemented by local efforts of technological learning and on the adoption of policies favoring a more dynamic specialization pattern (Cimoli and Correa, 2005; Fagerberg, 1994; Hausmann and Rodrik, 2003; UNCTAD, 2003).

Within this framework, Ricardian trade models with a continuum of goods are powerful tools for analyzing the role of technology in international trade; they bridge Keynesian (demand-led) growth, the balance-of-payments constraint and technological and structural change. In these models, countries specialize on the basis of the differences in labor productivity arising from technological asymmetries within industrial sectors. Countries that are closer to the technological frontier show much higher productivity in high-tech, innovation-driven sectors than laggard countries. At the same time, productivity differences will be lower in sectors in which technology is already standardized and, consequently, the technological frontier moves slowly. These considerations frame a setting where innovation dynamics and technology diffusion in the international economy determine a country's specialization pattern

In point of fact, Ricardian models results effective in studying convergence and divergence amongst countries in the international economy. In effect, in a two country model, one of which is the technological leader (North) and the other the follower (South), current account equilibrium implies that the relative North-South income must be a function of the number of goods that each country produces, *i.e.* a function of the two different specialization patterns. The evolution of relative income through time, i.e. the convergence or divergence in the international economy, will depend on how technological change redefines the location of production: if the South expands the range of goods that it produces towards more dynamic sectors (i.e. towards sectors with rising demand or productivity), there will be convergence.

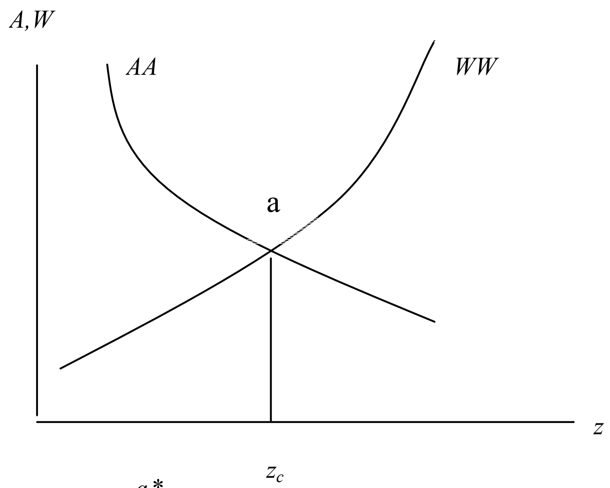
Moreover, Ricardian models may link the Schumpeterian perspective, with its focus on technology and structural change, and the Keynesian balance of payments constrained growth models, that highlight the role of demand in sustaining growth. In the Keynesian tradition, the specialization pattern is embedded in the income elasticities of demand for exports and imports (McCombie and Thirlwall, 1994), thus being the link between specialization patterns and demand implicitly present in these models. Ricardian models permit to look at elasticities as the outcome of a process of structural change. The elasticities are then expressed as a function of the parameters that define the relative rates of innovation and technology diffusion in the international economy. In what follows a simple model of convergence and divergence is presented.

a) The Ricardian Model and the Technological gap

The Ricardian model presented in this section is based on Dornbush *et al* (1977), and the subsequent Neo-Schumpeterian revisions of Cimoli (1988) and Dosi *et al* (1990). We assume a two-country model, where the North (N) and the South (S) differ in terms of their technological development, being the North the more advanced country. Both countries compete in the production of a large number of goods. Comparative advantage depends on relative labor requirements defined as $A(z) = \frac{a_z{}^*}{a_z}$, where a^*_z are the hours per worker required to produce one unit of good z in the North and a_z are the hours per worker required to produce one unit of the same good in the South. Relative labor requirements are a function of technology. The subscript $z \in [0,1]$ is defined in such a way that goods are ranked in a descending order in terms of the comparative advantage of the South. The slope of the *AA* curve reflects the rate at which the South looses its comparative advantage as the economy diversifies towards sectors that are more technology intensive. The *WW* curve represents relative wages $W= w/w^*$ between South (w) and North (w^*).

Figure 1 shows the curve AA that represents relative labor requirements and the curve of relative wages (WW), that both define the specialization pattern. Assuming that labor is the only factor of production, the exchange rate is constant and equal to 1, and the goods market is perfectly competitive, the South will produce the goods for which $A>W$. Thus, the South will produce goods ranging from z_0 to z_c while the North will start producing goods from z_c .

Figure 1. The Ricardian model



Note: The curve $A=\dfrac{a^*}{a}$ gives the relative labor requirements for producing one unit of good z in the North (a^*) and the South (a). The curve $W=\dfrac{w}{w^*}$ gives the relative nominal wage between South (w) and North (w^*).

It is assumed that the position of the *AA* curve depends on the technological gap defined as $G=\dfrac{Tn}{Ts}\geq 1$, where *Tn* and *Ts* are respectively, the technological levels of North and South. The evolution of the technological gap depends on the relative rates of innovation in the North and of technology diffusion towards the South. Following Fagerberg (1988) and

Narula (2004), technological spillovers from North to South are assumed to be a linear function of the inverse of the technological gap and the learning efforts in the South[6]:

$$(1)\quad \hat{G} = \rho - \mu\left(1 - \frac{1}{G}\right)$$

Where $\hat{G} = \frac{\dot{G}}{G}$ the proportional growth rate of the technological gap, ρ is the exogenous rate of growth of knowledge in the North and μ is the domestic effort of the South to master Northern technology. Both parameters are positive and constrained, so that $\mu > \rho > 0$.

Although the model is aggregate and not micro-founded, the parameters that define the evolution of the technological gap can be easily interpreted in the light of the Schumpeterian literature on social capabilities (Abramovitz, 1986) and National Systems of Innovation (Freeman, 1987). The parameters ρ and μ reflect the amount of resources allocated to R&D and the institutional setting in which technological learning proceeds in both countries. There is evidence pointing out that imitation does not occur automatically, but it is the result of investments in learning that may vary considerably across countries (Cimoli and Katz, 2002). These differences are reflected in μ. Alternatively, the parameters of the model can be seen as the equilibrium result of a micro process in which economic agents choose to become either innovators or bureaucrats, as in the Sah and Stiglitz (1988) model. In this case, the South will reach an equilibrium featuring a larger proportion of bureaucrats than the North, and this explains the asymmetry between North and South in terms of technological learning. The stability of the technological gap implies that:

$$(2)\quad \frac{\dot{G}}{G} = 0 \Rightarrow G^* = \frac{\mu}{\mu - \rho}$$

Equation (2) gives the equilibrium value of the technological gap (G^*) as a function of the parameters that define the effort for innovation in the North and for imitation in the South. It is straightforward that in equilibrium the gap will not be fully closed.

b) Productivity, wages and diversification

In what follows we address the role of technological gap in shaping the pattern of comparative advantages. It is assumed that the technological gap affects the position of the curve AA, as in the following equation:

[6] A more realistic assumption would be that of a nonlinear relationship between technological spillovers and the technological gap, as suggested by Verspagen (1993, chapter 5). Still, the linear assumption simplifies the model and helps to highlight how changes in the technological gap are related to changes in specialization and growth, which is the basic issue of this paper. Moreover, as suggested by Narula (2004), it can be assumed that the economy has already developed the minimum technological capability required to enter the catching-up stage. At this stage, the pace of learning is an inverse function of the technological gap. See also the classical paper by Nelson and Phelps (1966), which focuses on the role of one dimension of the NSI, the accumulation of human capital .in international technological diffusion.

$$(3)\ \frac{a^*(z)}{a(z)} = A(z) = \alpha - \beta G - bz$$

Where α, β and b are positive parameters and α > β + b.

A reduction in the technological gap shifts the *AA* curve to the right, increasing the relative labor requirements of the North for all goods *z* produced in the international economy. At this point, assumptions about how the *WW* curve behaves are needed. To start, let us assume that nominal wages are constant and therefore *WW* is horizontal – in other words, the relative nominal wage remains constant as *z* increases[7]. Constant nominal wages can be justified considering that the labor market in the "large" North is fairly resistant to changes in competitiveness in the "small" South, while the abundant supply of labor in the South allows it to boost employment rather than nominal wages when the economy grows[8]. Therefore:

$$(4)\ \frac{w}{w^*} = W = h$$

Where $0 < h \leq \alpha - \beta$. Since in equilibrium *A* must equal *W*, it is possible to get the specialization pattern (the set of goods produced in) of South and North as a function of the technological gap.

$$(5)\ z_c = \frac{\alpha - \beta G - h}{b}$$

If the technological gap is in equilibrium, then using equation (2) in (5) yields:

$$(5\ )\ z_c = \frac{(\alpha - h)(\mu - \rho) - \mu\beta}{(\mu - \rho)b}$$

This equation gives the pattern o specialization as a function of the exogenous parameters. The partial derivative of (5) with respect to μ is unambiguously positive, suggesting that the Southern economy can diversify the economy by intensifying its imitative effort. On the other hand, if the rate of innovation in the North suffers an positive exogenous shock, while the imitative effort in the South stays still at about the same level as before, then the technological gap and the number of goods produced in the North will expand at the expense of employment in the South.

c) Specialization and the external constraint

Now, the model allows studying how specialization shapes North-South relative income levels. This requires the study of the conditions necessary for international current account equilibrium. Equilibrium in the international economy (assuming the absence of capital flows) requires the current account of the two countries to be balanced. We assume that consumers spend exactly the same percentage of their nominal income in each type of *z*. good. If the

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[7] On the other hand, as it will be discussed later, despite nominal rigidity, real wages may be increasing as a result of productivity growth in both in the North and in the South.

[8] Under these assumptions, it is the level of employment in the South that endogenously adjusts so as to completely absorb the impact of changes in international competitiveness.

South produces goods for which $0 \leq z \leq z_c$ (and hence the North produce goods for which $z_c < z \leq 1$), then z_c will be the percentage of the nominal income that consumers, both in the North and in the South, spend on goods produced in the South. If the exchange rate is fixed and assumed unitary, then Southern exports will equal the Northern nominal income (y^*) times z_c (Obstfeld and Rogoff, 1996, p.240). Symmetrically, Southern imports will equal the Southern nominal income (y) times ($1-z_c$) (the latter being the share of the nominal income of the South that goes to buy Northern goods). Then, the current account equilibrium condition requires that $(1- z_c)y = z_c\, y^*$. The equilibrium condition in the international economy is as follows:

$$(6)\quad y = \frac{z_c}{1-z_c} y^*$$

Equation (6) gives the nominal income in the South that is consistent with external equilibrium as a function of the Northern nominal income and the degree o diversification of the Southern economy (the number of goods whose production is located in the South in relation with the total number of goods). This represents a Ricardian version of Thirlwall's Law (McCombie and Thirlwall, 1994, chapter 3), in which the elasticity parameters of the demand functions for exports and imports have been replaced by parameters that reflect the production diversification in the South. The economy will be constrained by external equilibrium, and if it fails to pass the test of international competitiveness, the result would be either less employment or lower wages. Since z_c depends on the technological gap (equation 5), then equation (6) can be written as:

$$(7)\quad \frac{y}{y^*} = \frac{u(G)}{b-u(G)}$$

where $u(G) = \alpha - \beta G - h$, ie. the relative North-South nominal income is as a function of the technological gap. The impact of changes in the technological gap on relative nominal incomes through deriving (7) with respect to G:

$$(8)\quad \frac{\partial(y/y^*)}{\partial G} = \frac{-b\beta}{(b-u(G))^2}$$

And (8) is negative. Moreover, equation (6) states that nominal incomes will be equal in North and South only in the special case in which the two countries produce exactly the same number of goods, $z_c = ½$.

d) Convergence and Divergence

By differentiating equation (6) with respect to time, it is possible to analyze how the evolution of the North-South relative income level is related to changes in the specialization pattern:

$$(9)\quad \hat{y} - \hat{y}^* = \frac{\hat{z}_c}{1 - z_c}$$

where cap on variables denote rates of growth ($\hat{y} = \dot{y} / y$). This equation stresses that for convergence to occur the South must be diversifying its economy. Moreover, as changes in specialization respond to adjustment in the technological gap, it results that income and technological convergence are interrelated, as the differentiation of (7) with respect to time shows, see equation 10)[9]

$$(10)\quad \frac{y}{y^*}(\hat{y} - \hat{y}^*) = \frac{-b\beta\dot{G}}{(b - u(G))^2}$$

Equation (10) shows that convergence ($\hat{y} - \hat{y}^* > 0$) will occur when the technological gap closes ($\dot{G} < 0$).

So far the discussion has focused convergence in nominal incomes. But, as according to the model's assumptions the principle of purchasing power parity (PPP) holds true in its strongest version (the Law of One Price), the model's conclusions can be extended to convergence in real incomes as well., In effect, nominal wages are constant in both countries and therefore they do not affect prices; consumers spend their nominal income in the same goods, and in exactly the same proportions; perfect competition assures that productivity growth fully translates into lower prices; and the exchange rate is constant. As a result, at any moment inflation rates are equivalent in the two countries, and the evolution of the North-South relative income in nominal terms will be the same as the evolution of relative income in real terms:

$$(11)\quad \hat{y}_R - \hat{y}^*_R = \hat{y} - \hat{y}^* + (\hat{p}^* - \hat{p})$$, and for $\hat{p} = \hat{p}^*$, then

$$(12)\quad \hat{y}_R - \hat{y}^*_R = \hat{y} - \hat{y}^* = \frac{\hat{z}_c}{1 - z_c}$$

where the subscript $_R$ indicates that the variable is expressed in real terms[10].

e) Flexible Relative Nominal Wages

So far nominal wages were assumed constant and changes in nominal income reflected adjustments in employment in the South. Let us assume now full employment both in the North and in the South and suppose that relative nominal wage adjusts to respond to changes in international competitiveness. Since labor is the only factor of production, its amount is

[9] where dots on the variables denote derivates with respect to time (*i.e.* $\dot{G} = \frac{dG}{dt}$).

[10] Annex 1 shows an example to illustrate the adjustment after a shock in one of the exogenous parameter.

constant, the followings hold: $y = wL$ and $y^* = w^*L^*$. Therefore, the current account equilibrium condition defined by equation (6) can be written as follows:

$$(13)\quad wL = \frac{z_c}{1-z_c}\, w^* L^*$$

The value of z_c as a function of G derives from equations (3) and (13) and the equilibrium condition $A=W=\dfrac{w}{w^*}$ (given L and L^*):

$$(14)\quad z_c = \frac{f(G) - \sqrt{[f(G)]^2 - 4b(\alpha - \beta G)}}{2b}$$

Where $f(G) = \alpha - \beta G + b + c > 0$, and $c = (L^*/L)$.

Although equation (14) is not as simple as equation (5), it does not affect the basic model's results. In particular, relative income levels continue to be described by equations (6) and (7), while the rate of nominal and real convergence are described by equations (9) and (10). The difference is that, in this case, convergence is related to changes in relative nominal wages that endogenously respond to the diversification in the South (while employment remains constant). Therefore:

$$(15)\quad \hat{y} - \hat{y}^* = \hat{w} - \hat{w}^* = \frac{\hat{z}_c}{1-z_c}$$

If one makes the additional assumption that the North is big enough so as to remain unaffected by structural change in the South, then nominal wages in the North will remain constant and the effects of new policies will be fully translated into an increase of nominal wages in the South. In this case, the mechanism of convergence will be a reduction in the gap between real wages in North and South. The Ricardian model gives rise to two testable predictions. These predictions stem from equations (6), (7), (9) and (10) and can be summarized as follows:

- *GDP per capita growth will be positively related to technological capabilities, which are represented by the parameter μ;*
- *GDP per capita growth will be positively associated with the diversification of the export structure towards technology-intensive sectors.*

f) Empirical Evidence

The empirical evidence that follows is based in econometric estimations for two different panel data: i) a two-year panel data (using the years 1990 and 2000) and ii) a 14-year panel data (including data for the whole period 1990-2003). The two-year panel data assesses the role played by National Innovation Systems in economic growth. The 14-year panel data tests the role of the specialization pattern.

The ArCo index, based on by Archibugi and Coco (2004), is proxy for technological learning. This Index is as a linear combination of three indicators related to different dimensions of NIS: (*Ia*) creation of technology; (*Ib*) technological infrastructure development and (*Ic*) human capital formation efforts[11]. As mentioned, the ArCo index is available only for two years, 1990 and 2000.

The second panel data (14-year series) [12] helps to study the role of international specialization using terms of trade, participation of agricultural raw materials in total exports[13] and participation of high-technology exports in total exports[14] as proxies for the degree of export diversification. Terms of trade are equal to the capacity to import minus export of goods and services in constant prices. A first econometric tests is run on the following equation:

$$(17)\ \hat{y}_{it} = \alpha_i + \beta_i ArCo_{it} + \varepsilon_{it}$$

Where $\hat{y}_{it}$ is the per capita GDP growth rate of country *i* at time *t*. Table 1 shows the results for Ordinary Least Squares (OLS), random and fixed effects estimations. Estimated parameters suggest that the Schumpeterian approach to Ricardian model is consistent with empirical evidence. In all cases the coefficient of the technological learning index is positive and significant. As stressed by the Schumpeterian literature, catching-up in the international economy in terms of technology and real incomes is a function of what has been broadly defined as the national innovation system.

Table 1. Economic Growth and Technological Capabilities

Variables / Estimation	Pooled Regression OLS	Fixed Effect	Random Effect	Fixed Effect with time dummies
Technological Learning	5.44**	3.46**	4.73**	4.36**
(Arco)	(0.35)	(0.37)	(0.25)	(0.61)
R2	0.71	0.57	0.63	0.58
Observations	174	174	174	174

Notes: ** significant at 5%

The Balance-of-Payments constrained approach suggests, in turn, that technological learning affects growth by allowing for the diversification of the export structure towards more

[11] The variable (*Ia*) includes number of patents per capita obtained in the United States and per capita number of scientific papers published by the residents of the country; (*Ib*) is a combination of three variables that seek to capture the development of the technological infrastructure: internet penetration, telephone penetration and electricity consumption; and (*Ic*) is a proxy for investment in human capital, including mean years of schooling, tertiary science and engineering enrolment, and the literacy rate.

[12] Data were obtained from UN COMTRADE Database and World Bank (2005).

[13] Agricultural raw materials comprise section 2 (crude materials except fuels) excluding divisions 22, 27 and 28 (crude fertilizers and minerals excluding coal, petroleum, and precious stones and metal ores and scrap) of the Standard International Trade Classification (SITC).

[14] The high-technology exports comprise exports from sectors that are intensive en R&D, namely aerospace, computers, pharmaceuticals, scientific instruments, and electrical machinery.

dynamic sectors. In other words, the demand-side must not be neglected. To test this hypothesis, the following econometric model is estimated:

$$(18)\ \hat{y}_{it} = \alpha_i + \beta_i PS_{it} + \varepsilon_{it}$$

Where *PS* is the vector of the three variables used as *proxies* for the dynamism of the specialization pattern.: terms of trade, participation of agricultural exports in total exports and participation of high-technology exports in total exports. We suppose that high-tech exports represent dynamic items in international trade, while agricultural exports tend to generate less technological externalities and also face a lower income elasticity of demand. And the econometric results are consistent with the hypothesis that specialization matters for growth. All coefficients are significant and have the expected signs (see Table 2).

Table 2. Economic Growth and Specialization

Variables / Estimation	Fixed Effect *(1)*	Fixed Effect *(2)*	Random Effect *(3)*	Random Effect *(4)*
Term of Trade	0.017***	0.017	0.009	0.010
	(0.014)	(0.027)	(0.027)	(0.029)
Agricultural Exports	-0.011	-0.10	-0.11**	-0.12**
	(0.09)	(0.08)	(0.04)	(0.03)
High Tech Exports	0.037**	0.038	0.034**	0.033**
	(0.012)	(0.019)	(0.011)	(0.010)
R2	0.12	0.24	0.13	0.16
Obs.	770	770	770	770

Notes: (2) Estimation with time dummies. (4) Estimation with regional dummies. ** significant at 5%; ** * significant at 10 %.

These econometric estimations confirm the predictions of the Ricardian model previously presented[15].

[15] However, future research based on a wider panel data would be beneficial. The authors are currently working on assembling a panel including new variables.

2 Structural change and technological capabilities

This section compares empirical evidence on the Latin American technological and structural change in a comparative perspective during the last 30 years focusing on production structure and exports' dynamism. The analysis is based on a sample composed by 17 countries; seven of which are from Latin America and represent more than 90% of Latin America's GDP. The analysis is based on the following variables: i) structural change, measured as the share of the value added of R&D intensive sectors in the total manufacturing added value, ii) R&D expenditures as % of GDP, iii) relative labor productivity in the manufacturing industry with respect to the US; iii) accumulated number of per capita patents registered in the USPTO, iv) changes in the international specialization pattern, measured by the Adaptability Index; and v) economic growth[16]. Table 3 presents the correlation matrix between these variables.

Table 3. Matrix of Variable Correlations

Variables	Structural Change[a]	Productivity Gap[a]	R&D	Patents	Adaptability Index [a]	GDP Growth
Structural Change[a]	1	0.63	0.52	0.36	0.63	0.70
Productivity[a] Gap		1	0.44	0.26	0.53	0.31
R&D			1	0.89	0.07	0.27
Patents				1	0.09	0.18
Adaptability Index [a]					1	0.46
GDP Growth						1

Source: Own elaboration based on Annex 2.
[d] Variation rates.

According to simple correlations structural change appears as highly correlated with GDP growth. At the same time, the intensity of structural change is closely related with R&D expenditure (relative to GDP) and the Adaptability Index. This suggests that the economies that increased the share of R&D intensive sectors in total manufacturing value added increased and that invested the more in innovation, grew faster.

Correlations between technological variables and economic growth are not as high as those between growth and the variables that grasp the characteristics of the production structure. This suggests that the effects of learning and innovation on growth are mediated by structural change. In what follows we give evidence of the asymmetries in structural change and technological efforts in Latin America with respect to emerging or frontier's countries.

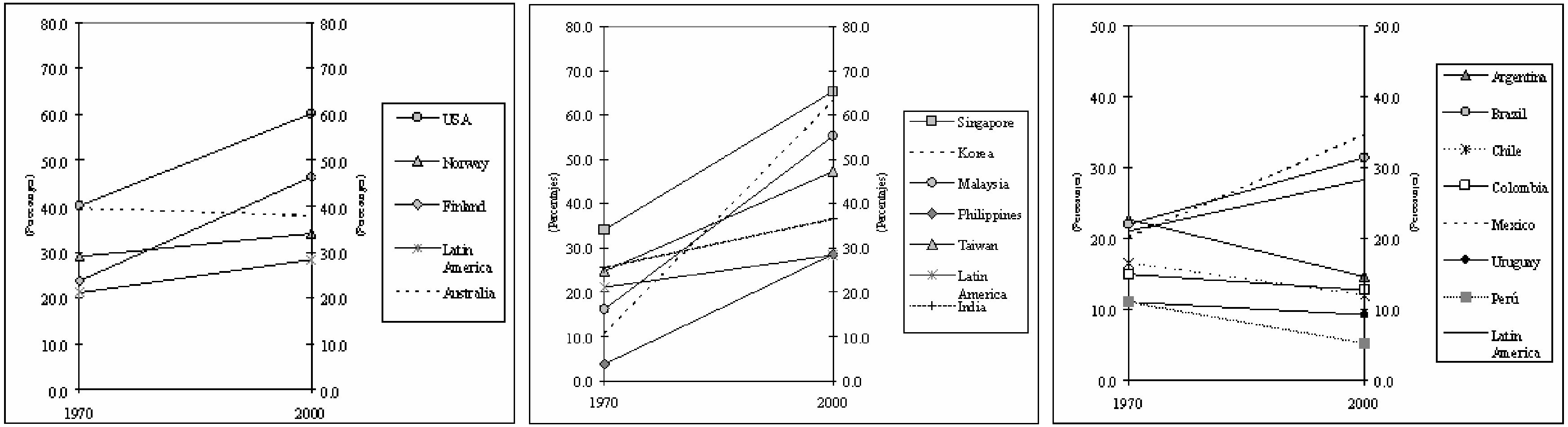
[16] See Annex 3 for the definition of the variables.

Manufacturing industry can be classified in three different categories: natural resource intensive, labor intensive and R&D intensive activities (see Annexes 2 and 3). The US, Finland, Korea, Malaysia, Singapore and Taiwan show the highest increase in the share of R&D intensive sectors in total manufacturing value added between 1970s and 2000. At the same time, almost all countries saw, during the same period, a reduction in the participation of labor-intensive activities in total manufacturing value added. Latin America, On the other hand, shows a quite stable production structure.

Figure 2 portrays the variation in the participation of R&D intensive activities in manufacturing value added between 1970 and 2000. Figure 2a compares Latin America with US, Norway, Finland and Australia. The weight of R&D intensive sectors increased in mature economies, like US and Finland from 40% to 60% and 23.8% to 46.4%, respectively. On the other hand in Latin America the participation of the R&D intensive sectors only increased from 21.1% to 28.3%. Figure 2b highlights the technological leadership of Asian countries where the participation of R&D sectors reaches 63%, 65.4% and 55.3% of total manufacturing value added in Korea, Singapore and Malaysia, respectively. Figure 2c helps to identify heterogeneity within Latin American countries. Between 1970 and 2000 the share of R&D sectors in Argentina, Colombia, Peru and Uruguay decreased, while it increased in Brazil and Mexico.

Figure 2. Participation of R&D intensive sectors by regions and countries, 1970 and 2000
(Percentages)

a) *b)* *c)*



Source: Own elaboration based on Annex 2.

Figure 3 looks at structural change from a different perspective. The production structure composition is measured in the Y-axis, where the cumulative share of natural resource intensive, labor intensive and R&D intensive activities is measured[17]. The X-axis measures labor productivity. Shifts along the X-axis reveal productivity changes, while movements along the Y-axis measure variations in the share of each kind of activity within total value added, i.e. structural change.

Figure 3a) compares Latin America with the US. The increase in productivity achieved by the US is much higher than that of Latin America. Differences are not limited to productivity; they also concern the production system. In 2000 in the US R&D intensive activities represented 60% of the industrial value and were, at the same time, the most productive activities. This is not the case for Latin America. There, natural resource intensive activities are the more productive ones and those that contribute the most to the generation of total manufacturing value added. Although in some Latin American countries the participation of R&D intensive activities increased, the intensity of this change is clearly less marked than the one that occurred in US and in catching up economies like the Asian ones.

The increasing share of R&D intensive sectors in manufacturing matched with productivity growth is the source for a virtuous process that generates and diffuses knowledge. Firms and sectors interact absorbing products and improving their production processes with greater technological content (Dalum, Laursen and Verspagen, 1999). Abramovitz and David (2001), for example, explain the variation in the pattern of growth in the US between 1800 and 1900 as a result of the modification in the sources of labor productivity growth; the importance of physical capital and tangibles was progressively less relevant in accounting for growth that the role of intangibles[18]. The US shifted from natural resource intensive specialization pattern to a pattern based on creation and diffusion of knowledge and intangibles mostly supported by the accumulation of technological and organizational capabilities.

The relevance of the specialization pattern in determining growth also finds empirical support in the analyses of cases of Korea, Singapore, Taiwan and Hong Kong (Nelson and Pack, 1999). These authors demonstrate that the higher growth rates in these countries derived from a substantial modification of their production structure due to an increase in the participation of R&D intensive activities in manufacturing and to the efforts directed to augment the capacity to gradually diffuse knowledge.

Figures 3b) and 3c) compare structural change in Korea with Brazil and Mexico. Both Latin American countries present a modest performance compared to Korea.

[17] Obviously the cumulative shares should sum 100, and the relative participation of each kind of activity can be obtained by difference in the Y-values.

[18] Abramovitz and David interpret economic growth in the US throughout the last two centuries as the result of the interaction of two key elements: i) what the authors call “global determining dynamics”, that refers to the transitional process of knowledge generation and diffusion and ii) the specific features of the national and regional US context characterized by a dynamic and flexible social organization.

Nevertheless, the industrial trajectories of Brazil and Mexico imply different strategies. In Brazil, market size and the active policies of the seventies supported the development of quite remarkable R&D intensive industries (Ferraz *et al*, 2004), whereas in Mexico attraction of foreign direct investments (FDI) and the integration to global productive systems, especially with the US, was the dominant aptitude (Capdevielle, 2005; Mortimore and Vergara, 2003).

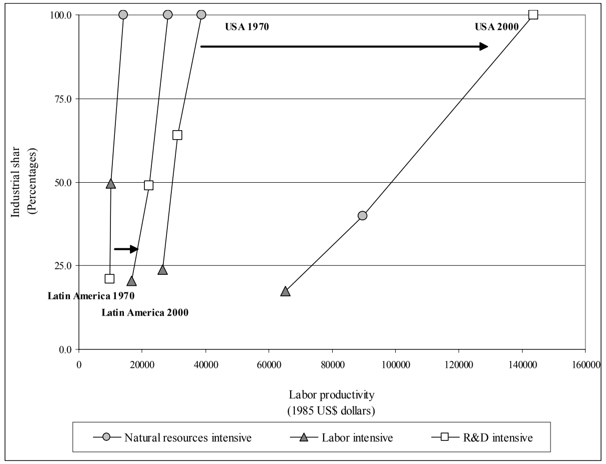
On the other hand, the Korean development strategy was deliberately oriented to the creation and accumulation of technological capabilities; the first industrial development plan dates back to 1962. Korean structural change resulted from an intentional strategy to foster a gradual industrialization that aimed to create the technical capabilities and to promote innovation privileging knowledge intensive industries. A selective combination of industrial and commercial policies was used to promote this knowledge-oriented industrialization. Figures 3b) and 3c) show the transformation of the Korean production structure and its gains in labor productivity[19].

Figure 3d) present the cases of Chile and Finland. In both countries, at the beginning of the seventies natural resource intensive activities dominated the production system, representing 61.7% of the Chilean manufacturing value added and the 52%of the Finnish one But in the decades after, the two countries followed different industrial trajectories. Finland experienced a radical technological upgrading of the production structure by increasing the participation of R&D intensive sectors from 23.8% to 46.4, and maintaining, at the same time, a significant share of natural resource intensive activities (these activities accounted for 40.4 % of total manufacturing value added in 2000). Conversely, Chile reinforced its specialization pattern in natural resources. In 2000, natural resource intensive activities accounted for 67.5 % of total manufacturing value added, while R&D intensive activities only represented the 12 %.

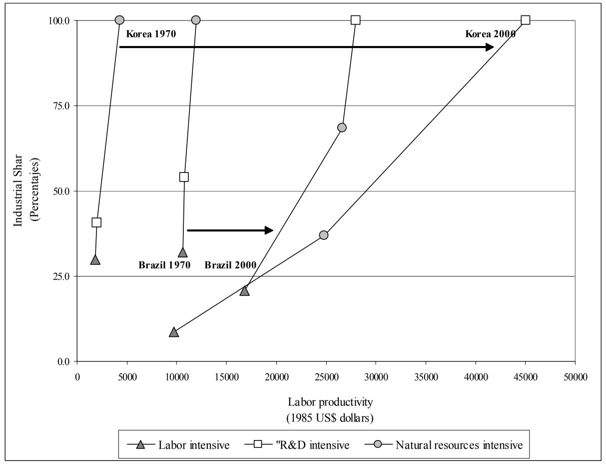
[19] See Krugman, 1994 for a discussion on the relative importance of capital accumulation and Nelson and Pack, 1999 for an analysis of the role of technical change as determinants of the impressive increase in production in South East Asia.

Figure 3. Structural Change and Productivity, 1970-2000
(Percentages and dollars)

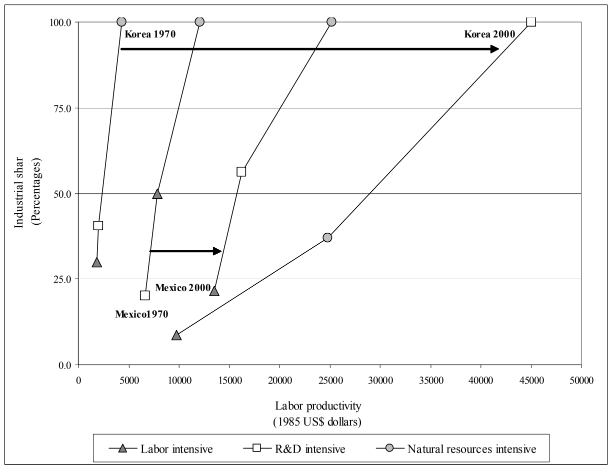
a) *Latin America and US*



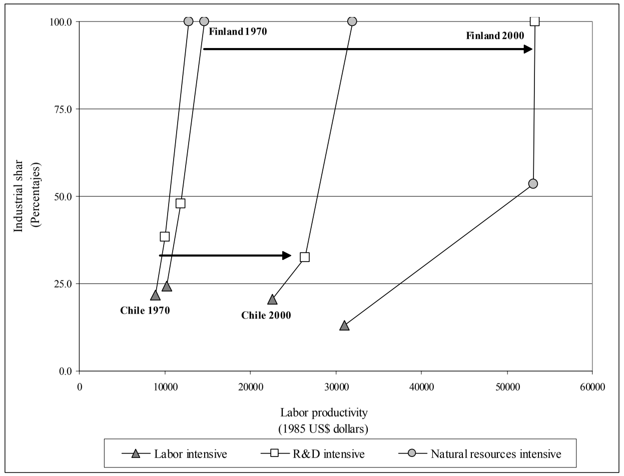
b) *Brazil and Korea*



c) *Mexico and Korea*



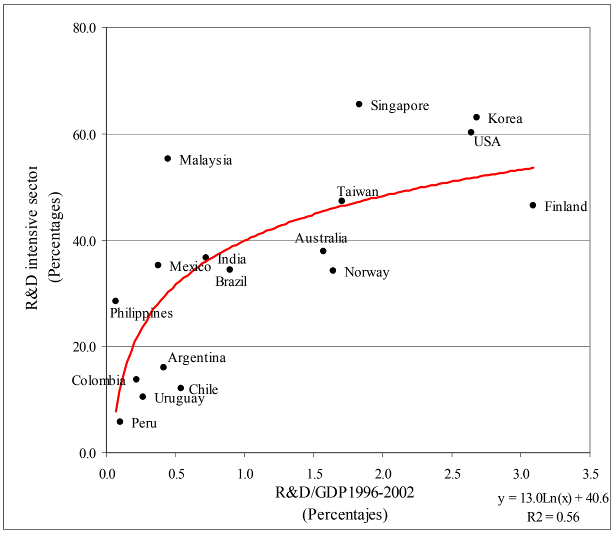
d) *Chile and Finland*



Source: Own elaboration based on *Programa de Análisis de Dinámica Industrial* (PADI), ECLAC.

There is an issue that has been implicitly involved in our discourse: the role of R&D spending. Actually, countries that experienced successful structural change showed, simultaneously and not surprisingly, increasing R&D expenditures. This is the typical case of Finland and Southeast Asian countries. This twofold process of changing the composition of the production structure and the raise in R&D expenditure stemmed, in general, from the application of a set of long-term coordinated policies directed at the accumulation of technological capabilities. Industrial and trade polices in Korea promoted a gradual upgrading in domestic technological capabilities and in Finland subsidies to technology intensive activities supported the structural change. In general, those countries in their period of industrialization experimented a sort of selective State intervention that fostered the reorientation of the production structure towards R&D intensive sectors (Kim, 1993; Ormala, 2001). Figure 4 shows a cross-country comparison between production structure and R&D expenditure. Most Latin American countries are concentrated at the bottom of the curve and are characterized by a low participation of R&D intensive sectors and by a reduced R&D expenditure (around 0.5% of the GDP).

Figure 4. R&D Intensive Sectors and R&D
(Percentages)



Source: Own elaboration based on Annex 2.

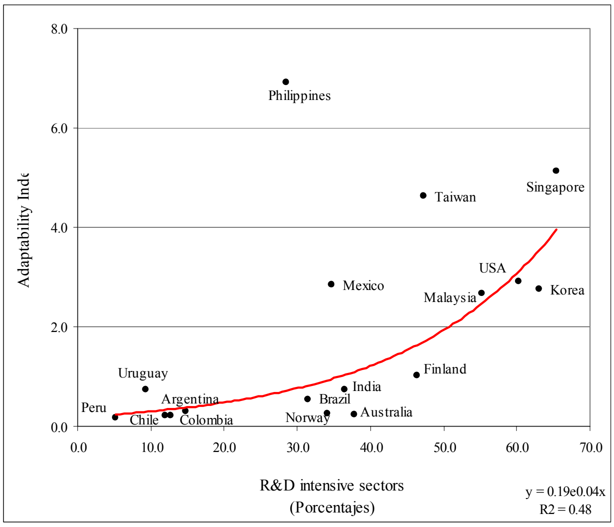
3 Trade and growth: the reinforcement of international specialization

Obviously the kind of international specialization is not independent from the characteristics of the production structure and the technological capabilities. The open economy setting on the one hand, favored the dynamics in the production structure presented in the previous section and on the other hand, induced the reinforcement of Latin America's international specialization, basically, according to two different patterns: the one proper of the Mexican Gulf and the other specific to Southern Cone. Mexico and Central American countries integrated their manufacturing and assembly activities into global chains, basically offering to Northern economies cheap labor (ECLAC, 2002; Cimoli and Correa, 2005; Mortimore and Peres, 2001; Reinhardt and Peres, 2000). On the other hand, Southern Cone countries (like Argentina, Brazil, Chile and Uruguay) reinforced their specialization in natural resources and standardized commodities. Plants in these industries are now highly capital-intensive but produce scant domestic value added.

Changes in the dynamism of international specialization can be described by the evolution of the Adaptability Index (see Annex 2). When this index is greater than one the participation of dynamic products (in international markets) exceeds the participation of stagnant products (sectors whose international demand grows at lower rates than the world average). A virtuous international specialization usually implies an increase in the Adaptability Index through time.

Figure 5 shows the relation between the participation of R&D intensive sectors and the Adaptability Index. Countries specialized in technology intensive sectors show higher values of the Adaptability Index (Southeast Asia and the US), whereas those specialized in segments of medium and low technological activities are characterized by a reduced index value (like Latin America excluding Mexico due to the *maquila* industries). In this respect, let us compare the peculiar cases of Mexico and the Philippines with Korea and Malaysia.

Figure 5. R&D Intensive Sectors and Adaptability Index
(Percentages)



Source: Own elaboration based on Annex 2.

Mexico, Malaysia and Korea show similar adaptability indexes, but they differ in terms of their production structure. The share of R&D intensive activities within total manufacturing value added is higher in Korea and Malaysia than in Mexico. We can argue that the Mexican adaptability is explained by exports originated from assembling activities that require low R&D expenditures and that generate weak spillovers effects. Capdevielle (2005) indicates that in Mexico the maquila industry has neither increased its productivity nor displayed strong linkages with the rest of the economy; in fact an increasing integration with international market does not imply increasing dynamism in all technological activties[20]. Conversely, in Korea and Malaysia the most dynamic exporting sectors are those with the highest share in total manufacturing value added, thus revealing stronger linkages between exports and domestic production.

Australia and Norway are other two peculiar cases. These countries show low adaptability but high R&D expenditures in terms of GDP. Their scant adaptability suggests that R&D expenditures have reinforced the external insertion in natural resource intensive sectors, which in general tend to be less dynamic. Philippines, in turn, stands out as a singular case due to the high degree of adaptability and the reduced participation of R&D intensive sectors in the production structure (28,5%). As in Mexico, the increase in the share of R&D intensive activities derives from FDI and assembly activities. These differences in countries' performances may help to identify different typologies of international specialization, according to the participation of natural resource intensive activities in total exports and R&D efforts.

Table 4. Trade and growth: a typology based on factors endowment or technological capabilities: A typology

	Natural resources intensive sectors [a]	**R&D intensive sectors** [b]
High R&D	Australia Norway	Korea, Taiwan, United States, Finland, Singapore
Low R&D	Argentina, Brazil, Chile, Colombia, México, Peru, Uruguay, Philippines, India	Malaysia

Source: own elaboration.
[a] Principal industrial activities in these countries are natural resources intensive, see Annex 2.
[b] Principal industrial activities in these countries are R&D intensive, see Annex 2.

According to international specialization patterns and technological efforts countries can be classified in terms of two basic types of growth strategies. The first one is based on taking advantage of the economic rents conferred by a privileged access to abundant factors of production, namely cheap labor or natural resources endowment. Countries that follow this strategy will tend to concentrate their efforts in maintaining or

[20] Ciarli and Giuliani (2005) reach to similar conclusion for the case of Costa Rica. The diversification of exports toward the electronics components and medical instrument sectors due to the attraction of foreign direct investments, have not been accompanied by significant technological and production linkages with domestic companies.

extending their participation in natural resources intensive sectors. In some cases, especially when natural resources are abundant but labor is scarce, significant technological efforts may be required to boost labor productivity. Some production linkages can arise spontaneously, but if those countries fail to actively encourage structural change it is likely that their specialization pattern will not automatically create the incentives to to shift towards more sophisticated technological production stages and activities.

The second type of strategy is based on trying to extract rents from knowledge, which must be continuously recreated as new paradigms arise and/or imitators gradually erode the dominant position reached by the innovator. Dynamic competitive advantages predominate in this type of strategy, as described by Schumpeter. Although the initial advantage can be based on some abundant factor, structural changes in the production system is continuous and it pushes for an increasing participation of R&D intensive activities within manufacturing.

In the ling term, the strategy based on fostering R&D intensive sectors induces higher rates of growth than the strategy of creating economic rents out of the relative abundance of natural resources or cheap labor. However, if a country benefits from natural resource abundance, this does not necessarily implies that the *dutch disease* or any other "natural resources curse" will affect it.

Societies face different options and they can choose between a set of possible growth trajectories. This choice– which has to do with complex variables related to institutions and political economy and their interplay with the economic structure and the dynamics of technological progress at each point in time - is more important in the long term than initial endowments. Abundance of resources can sustain growth without significant efforts for learning during a certain period, but in the long term economic rents derived from these resources tend to be eroded. Growth is sustainable only if backward and forward linkages are created, as it was anticipated by Hirsmann (1977) and by the "staples theory", and if the initial advantage is used to build up technological advantages.

4 Conclusions

A North-South Ricardian growth model in which the specialization pattern depends on the technological gap is an interesting framework for discussing convergence and divergence between central and peripheral countries. Convergence requires deep and well-built local efforts to foster learning and the development of technological capabilities in the South. This strengthening of National Innovation Systems aims at reducing the technological gap and diversifying the export structure towards more dynamic secors in terms of technological paradigms and demand growth. Assuming that comparative advantages are a function of the initial technological gap and the relative efforts in innovation in the North, and catching-up in the South, the model lead to a set of results that are consistent with the Schumpeterian hypothesis that links growth to technological capabilities. And consistency extends also to the Keynesian (demand based) perspective in which growth requires the transformation of the specialization pattern in order to ease the balance of payments constraint.

Learning and innovation reshape international competitiveness and allow countries to exploit the opportunities of international trade and growth. Moreover, technological efforts are mediated by the transformation of the production structure. A structural change that promotes sectors that create and diffuse technology allows to capture the opportunities of international demand dynamism. Convergence requires that the economies are able to transform their production structure, and look for rents generated by knowledge and learning activities. In that transformation, R&D intensive sectors must reach an increasing weight in the industry being a source of externalities and spillovers.

The existence of abundant natural resources or cheap labor can sustain high rates of growth during a certain period without requiring high R&D investments. However, changes in the international economy and demand patterns are likely to expose countries pursuing this strategy to vulnerabilities, because, in the long term, this behavior reduces the structural capacities of capturing the opportunities of technological progress. Actually, rents derived from knowledge, which are cumulative by nature, can be continuously re-created, redefining the conditions for allowing entrance in new markets. On the other hand, when rents are purely based on the relative abundance of resources, the capacities to induce or respond to shocks and changes is reduced, since the country basically lacks the technological capabilities necessary to readapt the production system to changing contexts.

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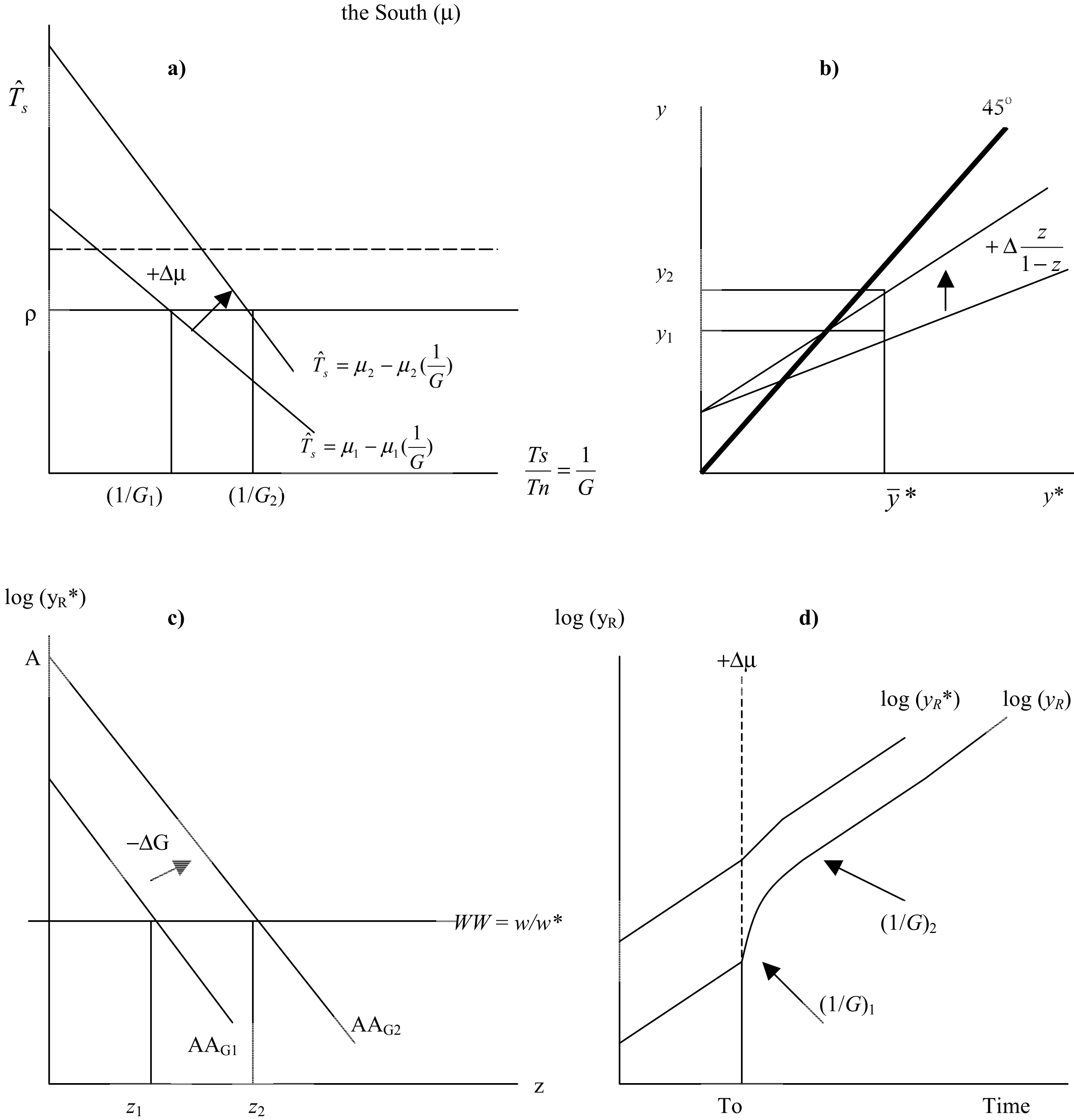
Annex 1. **Effects of an Increase in the Technological Learning Effort in the South**

Figures A1 show the co-evolution of the technological gap, the specialization pattern and growth in real terms after a positive shock on the rate of technological learning in the South, due, for instance, to a change in policies that increases Southern technological efforts (from μ_1 to μ_2). The policy-induced rise in μ shifts the $\hat{T}s$ curve to the right, thereby starting a gradual process of reduction of the technological gap as it moves towards its new (lower) equilibrium level. In Figure a) this is represented by an increase in the inverse of the equilibrium technological gap ($1/G$), from ($1/G_1$) to ($1/G_2$), where $G_2 < G_1$. As the technological gap falls, the specialization pattern changes and new activities are taken over by the South: this is represented by an increase in the borderline good z, from z_1 to z_2 (that correspond, respectively, to the equilibrium levels of the technological gap G_1 and G_2). The new equilibrium level of z implies that nominal income in the South will be higher for any nominal income in the North, without compromising external equilibrium. For simplicity, in Figure c) the nominal income in the North is assumed to exogenously given at $\bar{y}*$. As the North is a big country whose levels of employment and nominal wages are little affected by changes in Southern exports, this simplification does not compromise the validity of the exercise. Given $y*$, it is easy to pinpoint the equilibrium nominal income in the South using equation (6). The 45^o line gives the set of points for the special case in which zc = ½ and nominal incomes in North and South will be exactly the same (perfect convergence).

Figure d) looks at the dynamics of convergence. It plots the natural logarithm of real incomes in North and South against time and traces the impact on growth of the change of policy in the South in favor of faster technological learning. Initially, the technological gap is in equilibrium at G_1 and both countries grow in real terms at the same rate as the exogenous rate of technological progress in the North. Thus, ρ is the angular coefficient of the parallel straight lines that represent the logarithm of real income in North and South plotted against time. At the moment T_0, μ jumps from μ_1 to μ_2. As the South begins to diversify its production structure ($\hat{z} > 0$), employment grows in the South ($\hat{L} = \frac{\hat{z}}{1-z}$), giving rise to a higher nominal income, thereby reducing the distance with respect to nominal income in the North. Real income in the South moves upwards as well, reflecting both the increase in nominal income due to the expansion of employment and the fall in the price levels (related to the acceleration of productivity growth in the South). This increase in real income in the South is higher than in the North, since the latter only benefits from the fall in the inflation rate (the difference, which represents the convergence rate, being precisely the growth of employment in the South). Thus, the new policy in the South brings about a process of convergence in terms of both technology and income levels ($\dot{G} < 0$ and $\hat{y}_R - \hat{y}_R* > 0$). After some time the effect of the shock is absorbed, the technological gap and the specialization pattern stabilize again, and both countries are back to their previous growth path (in which they grow at the same exogenous rate given by technical progress in the North).

Figure A1. Convergence Effects of an Increase in the Technological Learning Effort in the South (μ)



Note:
Figure a) describes the impact of an increase in μ (+Δμ) on the equilibrium technological gap. Figure b) depicts how the fall in the technological gap (-Δ*G*) affects the specialization pattern, leading to the diversification of the economy (from z_1 to z_2). This in turn eases the current account constraint, as represented in Figure c). Figure d) shows the evolution through time of real income in North and South. It can be seen that the reduction in the technological gap produces a period of convergence leading to a smaller income per capita difference between North and South in equilibrium.

Annex 2. **Development Patterns**

Countries	INDUSTRIAL STRUCTURE				TRADE					TECHNOLOGY		GROWTH			
	1.- Structural Change			2.- Productivity Gap	3.- Export Specialization			4.- Adaptability Index		5.- R&D (%GDP)	6.- Patents	7.- GDP Growth (per capita)			
	Sectors	1970	2000	1970-2000	Categories	1985	2002	1985	2002	1996-2002	Acum.1977-2003 (mill/inhab.)	1970-1980	1981-1990	1991-2003	1970-2003
Latin America[a]	1. Natural Resources 2. Labor 3. R&D	50.3 28.6 21.1	51.0 20.6 28.3	-1.7	1. Natural resources 2. Low tech. manuf. 3. Medium tech. manuf. 4. High tech. manuf. 5. Others	73.3 7.9 12.2 4.3 2.3	43.6 13.9 25.1 14.4 3.0	0.22	0.98	0.37	5,425 (13.4)	6.0 (2.5)	1.2 (-0.9)	3.5 (1.4)	3.66 (1.36)
Argentina	1. Natural Resources 2. Labor 3. R&D	54.8 22.6 22.7	69.9 15.4 14.7	-0.4	1. Natural resources 2. Low tech. manuf. 3. Medium tech. manuf. 4. High tech. manuf. 5. Others	77.7 10.9 8.0 2.7 0.7	71.8 8.6 16.3 2.1 1.2	0.16	0.30	0.42	1,072 (29.8)	3.04 (1.42)	-1.38 (-2.75)	3.10 (2.08)	1.76 (0.44)
Brazil	1. Natural Resources 2. Labor 3. R&D	46.0 32.0 22.0	47.7 20.8 31.4	-1.5	1. Natural resources 2. Low tech. manuf. 3. Medium tech. manuf. 4. High tech. manuf. 5. Others	61.3 13.4 21.3 3.2 0.8	53.2 11.6 23.1 10.0 2.1	0.23	0.55	0.90	1,599 (9.1)	8.53 (5.98)	1.65 (-0.33)	2.32 (0.93)	4.13 (2.20)
Chile	1. Natural Resources 2. Labor 3. R&D	61.7 21.8 16.6	67.5 20.5 12.0	-1.4	1. Natural resources 2. Low tech. manuf. 3. Medium tech. manuf. 4. High tech. manuf. 5. Others	92.2 1.4 2.9 0.4 3.1	88.5 2.8 6.1 0.7 1.9	0.05	0.22	0.54	214 (14.3)	2.99 (1.33)	3.95 (2.28)	5.68 (4.18)	4.30 (2.70)
Colombia	1. Natural Resources 2. Labor 3. R&D	51.0 34.0 15.0	59.7 27.6 12.7	-1.2	1. Natural resources 2. Low tech. manuf. 3. Medium tech. manuf. 4. High tech. manuf. 5. Others	88.9 4.3 4.3 0.5 2.0	66.2 12.0 14.5 2.72 4.5	0.11	0.22	0.22	208 (4.7)	5.66 (3.21)	3.60 (1.48)	2.51 (0.62)	3.85 (1.71)
Mexico	1. Natural Resources 2. Labor 3. R&D	50.0 29.8 20.2	43.7 21.6 34.7	-1.6	1. Natural resources 2. Low tech. manuf. 3. Medium tech. manuf. 4. High tech. manuf. 5. Others	56.6 6.6 22.9 10.9 3.0	17.3 14.3 38.5 26.0 3.9	0.46	2.85	0.38	2,166 (21.2)	6.69 (3.62)	1.88 (-0.22)	2.85 (1.23)	3.81 (1.58)
Peru	1. Natural Resources 2. Labor 3. R&D	57.5 31.4 11.1	60.7 34.0 5.2	-4.7[b]	1. Natural resources 2. Low tech. manuf. 3. Medium tech. manuf. 4. High tech. manuf. 5. Others	86.5 7.10 3.9 0.5 2.0	79.4 14.6 2.6 0.5 2.9	0.4	0.18	0.10	114 (4.2)	3.86 (1.06)	-0.48 (-2.64)	3.78 (1.96)	2.55 (0.32)
Uruguay	1. Natural Resources 2. Labor 3. R&D	56.7 32.3 11.0	69.6 21.1 9.3	-1.4	1. Natural resources 2. Low tech. manuf. 3. Medium tech. manuf. 4. High tech. manuf. 5. Others	41.3 22.3 5.1 0.6 30.7[g]	59.9 24.1 9.4 3.6 3.0	0.43	0.75	0.27	52 (15.8)	2.99 (2.58)	0.15 (-0.48)	1.46 (0.79)	1.57 (1.01)
Australia	1. Natural Resources 2. Labor 3. R&D	37.9[c] 22.5[c] 39.6[c]	40.5 21.7 37.8	-1.8[c]	1. Natural resources 2. Low tech. manuf. 3. Medium tech. manuf. 4. High tech. manuf. 5. Others	83.5 3.2 6.1 3.0 4.2	73.9 5.1 9.8 5.4 5.8	0.10	0.25	1.57	14,725 (775.0)	3.17 (1.49)	3.06 (1.53)	3.54 (2.34)	3.28 (1.82)

Korea	1. Natural Resources 2. Labor 3. R&D	59.3 29.9 10.7	28.5 8.6 63.0	4.0	1. Natural resources 2. Low tech. manuf. 3. Medium tech. manuf. 4. High tech. manuf. 5. Others	12.8 47.0 24.2 14.7 1.3	12.7 15.3 32.1 38.0 1.9	1.11	2.76	2.68	29,437 (626.3)	7.40 (5.47)	8.74 (7.48)	5.83 (4.92)	7.19 (5.85)
US	1. Natural Resources 2. Labor 3. R&D	36.0 23.9 40.1	22.4 17.4 60.2	.	1. Natural resources 2. Low tech. manuf. 3. Medium tech. manuf. 4. High tech. manuf. 5. Others	29.8 6.5 34.5 25.0 4.2	19.7 10.8 34.9 30.6 4.0	1.40	2.92	2.64	2,132,548 (7,353.6)	3.01 (1.94)	3.27 (2.30)	3.00 (1.79)	3.08 (1.99)
Philippines	1. Natural Resources 2. Labor 3. R&D	84.5 11.6 3.9	59.8[d] 11.6[d] 28.5[d]	2.9[d]	1. Natural resources 2. Low tech. manuf. 3. Medium tech. manuf. 4. High tech. manuf. 5. Others	51.4 18.5 6.5 21.5 2.1	10.4 11.4 7.8 68.6 1.8	0.76	6.92	0.07	240 (2.96)	5.73 (2.87)	1.80 (-0.61)	3.28 (1.01)	3.64 (1.14)
Finland	1. Natural Resources 2. Labor 3. R&D	52.0 24.2 23.8	40.4 13.2 46.4	0.5	1. Natural resources 2. Low tech. manuf. 3. Medium tech. manuf. 4. High tech. manuf. 5. Others	57.5 14.4 20.7 6.3 1.1	39.5 8.5 20.2 29.4 2.4	0.36	1.03	3.09	10,008 (2,001.6)	4.05 (3.74)	3.06 (2.62)	1.91 (1.56)	2.94 (2.58)
India	1. Natural Resources 2. Labor 3. R&D	39.2 35.2 25.6	40.0 23.5 36.5	-0.2	1. Natural resources 2. Low tech. manuf. 3. Medium tech. manuf. 4. High tech. manuf. 5. Others	58.2 34.5 4.4 1.9 1.0	42.6 38.9 11.4 5.7 1.4	0.34	0.73	0.72	1,669 (1.7)	3.27 (0.94)	5.81 (3.59)	5.61 (3.80)	4.91 (2.81)
Malaysia	1. Natural Resources 2. Labor 3. R&D	51.0 13.9 16.1	35.2 9.4 55.3	-2.2	1. Natural resources 2. Low tech. manuf. 3. Medium tech. manuf. 4. High tech. manuf. 5. Others	67.6 6.4 7.4 17.3 8.7	18.2 8.6 13.8 58.0 15.2	0.34	2.68	0.45	356 (14.8)	7.70 (5.16)	6.03 (3.11)	6.32 (3.82)	6.68 (4.04)
Norway	1. Natural Resources 2. Labor 3. R&D	47.8 23.1 29.1	49.8 16.1 34.1	-2.5	1. Natural resources 2. Low tech. manuf. 3. Medium tech. manuf. 4. High tech. manuf. 5. Others	74.1 4.9 16.0 3.7 1.3	78.6 3.2 11.3 5.2 1.7	0.20	0.27	1.64	4,610 (922.0)	4.55 (3.98)	2.63 (2.26)	3.22 (2.64)	3.48 (2.96)
Singapore	1. Natural Resources 2. Labor 3. R&D	46.6 19.3 34.1	17.1 17.6 65.4	-0.9	1. Natural resources 2. Low tech. manuf. 3. Medium tech. manuf. 4. High tech. manuf. 5. Others	36.5 8.9 18.8 32.3 3.5	15.9 5.1 16.3 58.4 4.3	0.92	5.12	1.83	2,098 (49.9)	9.35 (7.70)	7.44 (4.94)	6.06 (3.38)	7.53 (5.24)
Taiwan	1. Natural Resources 2. Labor 3. R&D	42.7[c] 32.6[c] 24.7[c]	38.0 14.6 47.3	0.2[c]	1. Natural resources 2. Low tech. manuf. 3. Medium tech. manuf. 4. High tech. manuf. 5. Others	13.6 46.8 21.3 17.0 1.3	6.2 19.6 24.6 47.8 1.8	1.65	4.62	1.71[e]	40,746 (1,852.1)	10.2	8.1	6.3[f]	8.4[f]

Source: own elaboration. For source details, see Annex 3.
[a] Correspond to Latin American countries included in the table.
[b] Correspond to 1996, and 1970-1996 for productivity gap.
[c] Correspond to 1980, and 1980-2000 for productivity gap.
[d] Correspond to 1996, y 1970-1996 for productivity gap.
[e] 1996-1998 average.
[f] Average value until 1996.

Annex 3. **Database Sources**

1. *Structural Change*

Manufacturing is classified in three sectors: Natural Resource, Labor and R&D intensive. Structural change is measured by the change in the participation of the R&D intensive sector between 1970 and 2000 in total manufacturing value addedd. Statistic information comes from the *Programa de Análisis de la Dinámica Industrial* (PADI, ECLAC) for Argentina, Chile, Brazil, Colombia, United States and Mexico; and from the INDSTAT3 Industrial Statistics Database from the United Nations Industrial Development Organization (UNIDO, www.unido.org) for Malaysia, Taiwan, India and Singapore; and from STAN Database, Industrial Structural Analysis of the Organization for Economic Cooperation and Development (OCDE, www.ocde.org) for Australia, Korea, Spain, Finland and Norway. According to the International Standard Industrial Classification (ISIC rev.2), industrial sectors are classified as follow:

a) *Natural resource intensive*: 311, 313 y 314; 331, 341, 351, 353, 354, 355, 362, 369, 371 and 372.

b) *Labor intensive*: 321,322, 323, 324, 332, 342, 352, 356, 361 and 390.

c) *R&D intensive*: 381, 382, 383, 384 and 385.

For the cases of Singapore and those based on the STAN database, sectors 361 and 362 are excluded.

It should be noted that:

For Australia: 355 is included in labor intensive and 371 and 372 are classified within natural resource intensive sectors.

In Korea: 352 and 356 are included in natural resource intensive sectors, and 371 and 372 in R&D intensive activities.

For Finland and Norway: 355 is classified within labor-intensive sectors and 371 372 in R&D intensive activites.

2. *Productivity Gap*

It corresponds to the annual average growth of the ratio between *i* country labor productivity and US labor productivity for 1970-2000. (ie, average rate of growth of $A=Prod._i/Prod._{us}$). (*Source: PADI, ECLAC*).

3. *Export Specialization*

Correspond to the export composition, according to groups of products (*Source: TradeCan 2005, ECLAC)*. The products groups are defined as followed:

a) Natural resources: basic products of simple processing (includes concentrates) and natural resources manufacture exports.

b) Low technology manufactures: products of textile and apparel cluster plus other associated to paper, glass and steel, and jewelry.

c) Medium technology manufactures: products of automotive, processing and engineering industries.

d) High technology manufactures: products of electronic cluster and pharmaceutical products, turbines, airplanes and instruments.

4. *Adaptability Index*

The adaptability index is defines as I=Xd/Xe; where Xd is the participation of the dynamic products in the exports of each country, and Xe is the participation of the stagnated products (ie.,Xd+Xe=100). The dynamic products are those that increased their participation in the world-wide imports between 1985 and 2002, whereas stagnated ones are those that reduced it. (Source: TradeCan 2003).

5. *Research and Development (R&D)*

It Corresponds to R&D average expenditure over GDP between 1996 and 2002. *(Source: United Nations for the Education, Sciences and Culture (UNESCO, www.unesco.org) and Latin American Network of Indicators of Science and Technology (RICYT, www.ricyt.org).*

6. *Patents*

It corresponds to the number of patents by "inventions" granted by the Office of Patents and Trademark from the United States to residents of each country between 1977 and 2003. Between parentheses, number of patents by million inhabitants is specified. *(Source: USA Patents Office, www.uspto.gov).*

7. *Growth*
Gross Domestic Product growth *(Source: WDI, World Bank)*.